



Landfill Gas Overview

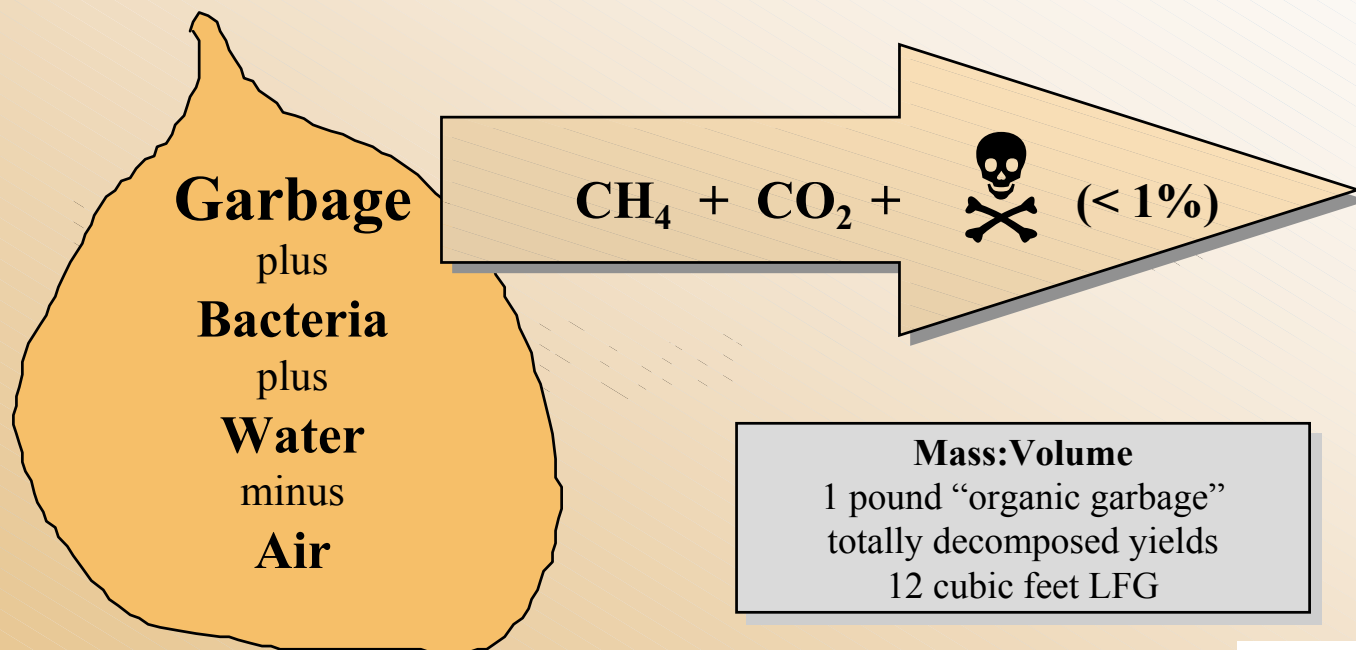
Natural Gas Vehicle Technology Forum
Dallas, TX

January 28, 2003

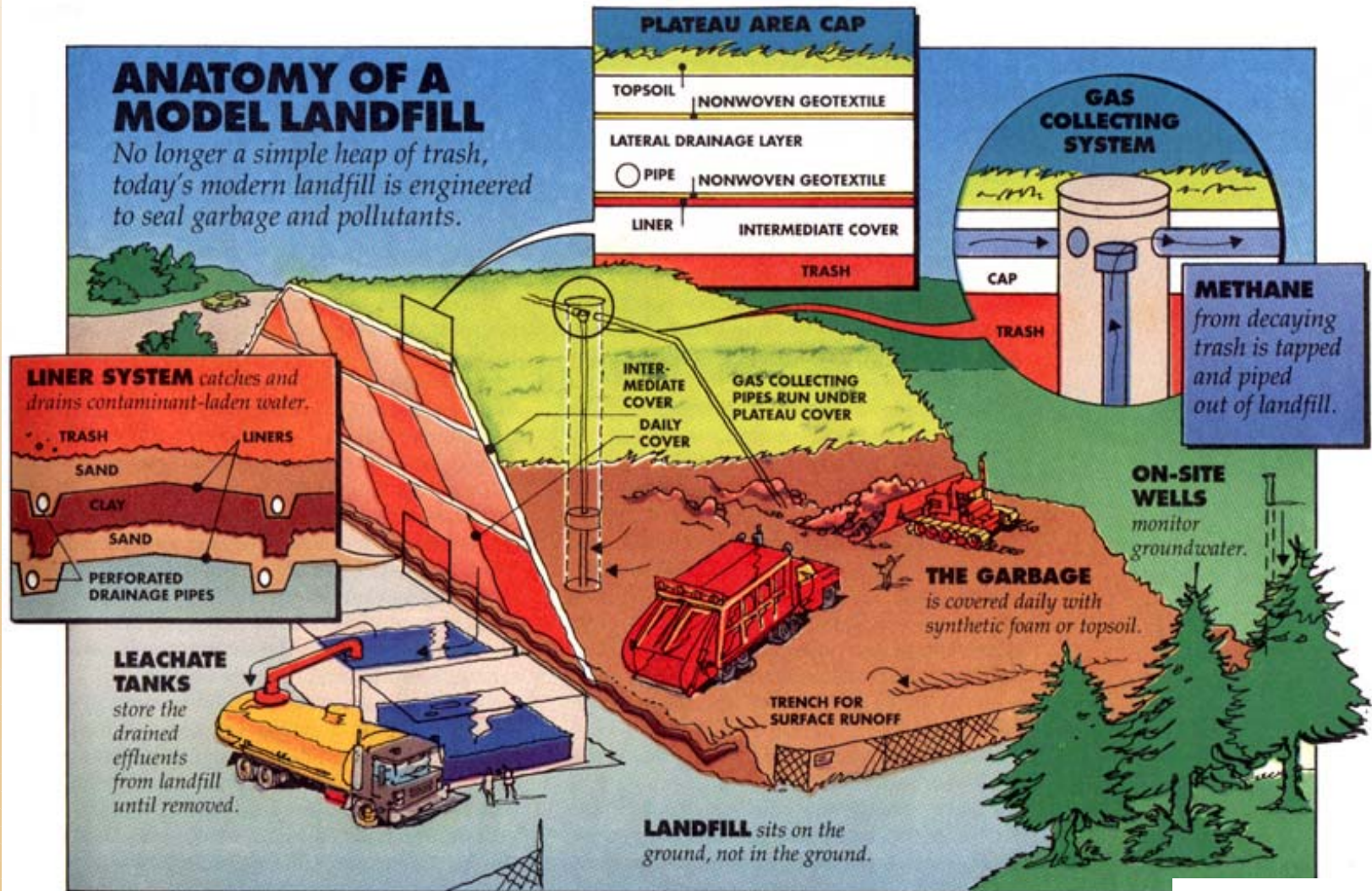
Dr. Jim Wegrzyn
Brookhaven National Laboratory

Landfill Gas Origin

LFG is created when organic waste in a landfill naturally decomposes. This gas consists of ~ 50 percent methane (CH₄), ~40 percent CO₂, ~10% other gases, and a small amount of organic compounds. Instead of allowing LFG to escape into the air, it can be captured, converted, and used as an energy source.



Modern Landfill



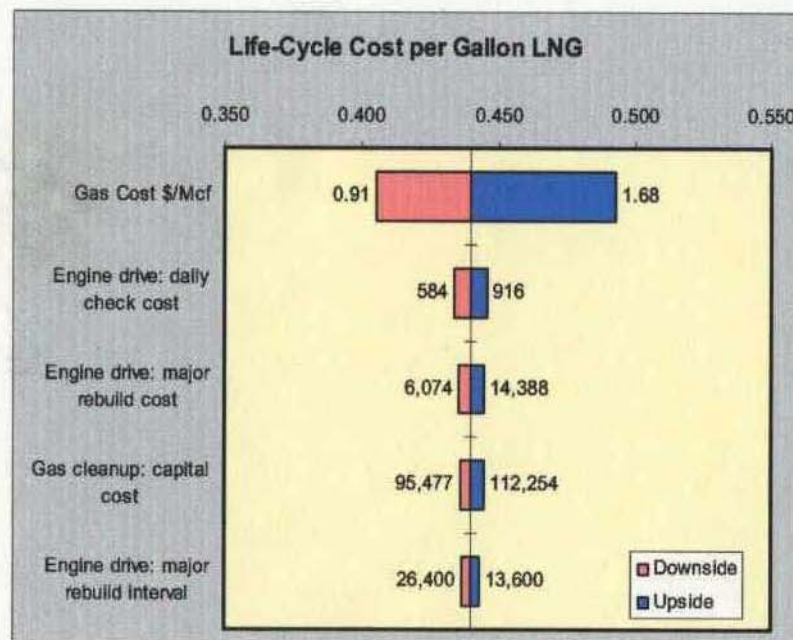
Why LFG to LNG?

- As of August 2002, EPA lists over 330 LFG projects, with another 500 landfill gas recovery projects feasible
- Converting waste to energy makes economic sense and is good public/environmental policy
- When used as a transportation fuel, LNG has a higher market value than pipeline gas
- Refuse haulers are a captive market for LNG from LFG
- Excess LNG and liquid CO₂ are also marketable
- IRS has classified landfill gas as a renewable energy source (tax advantage)

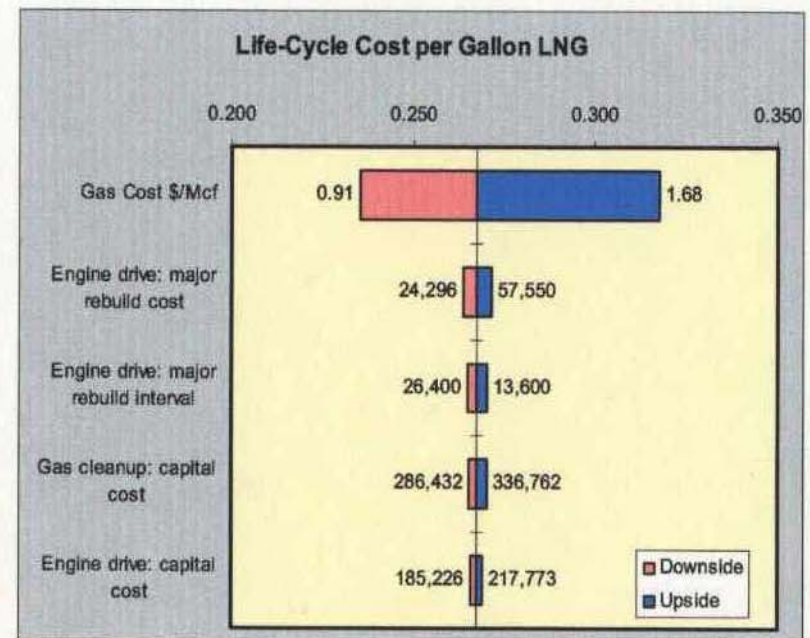


GTI's Cost Analysis

- 1,000 gal/day
 - \$0.44/gal life-cycle cost



- 5,000 gal/day
 - \$0.27/gal life-cycle cost



Questions Concerning LFG Recovery

- Several types of cleanup systems are needed – acid-gas, water, containments, bulk CO₂, and trace CO₂
- Several types of liquefiers are available, such as turbo expanders (high pressure) and mixed refrigerant (low pressure)
- System integration is the key
- Capital/ Maintenance/ Operation costs are unknown, but 10,000 gal/day unit generates \$5,000/day revenue
- Develop synergisms with other revenue-producing products like liquid CO₂ and peak electrical power generation



DOE Answers to LFG Questions

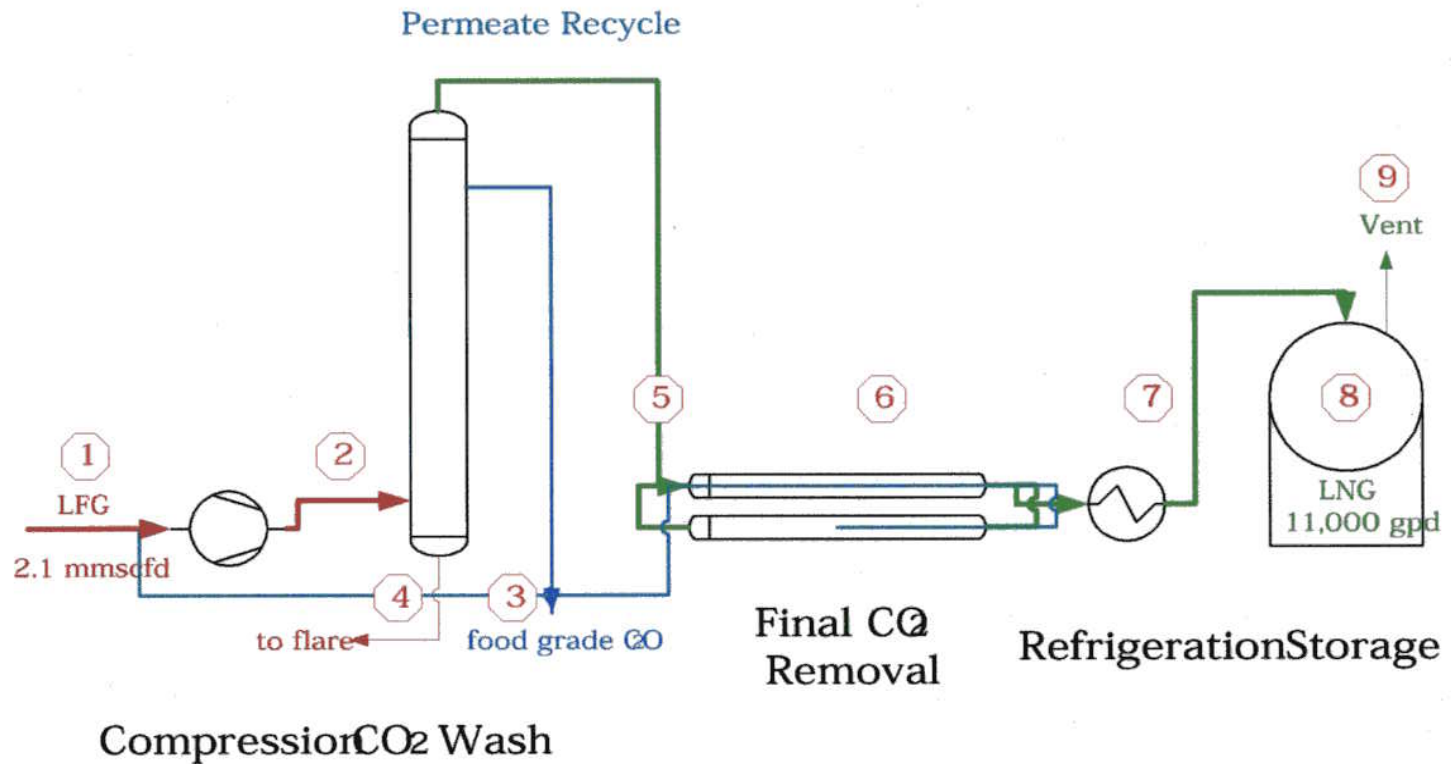
PARTNERING WITH:

- **Waste Management, Applied LNG Technologies, and State of Pennsylvania at the Arden, PA Landfill for operation and maintenance data**
- **Acrion, Mack Truck, and Air Products for 10,000 gal supply of LNG from the Burlington, NJ landfill using CO₂ wash technology for engine fuel quality test**
- **INEEL and PG&E on developing the cyclone removal of trace amounts of CO₂**
- **Supported in part Cryogenic Fuel System LNG recovery from the Hartland landfill, B.C. for adsorbent gas cleanup and turbo-expander liquefier**



Acrion's LFG to LNG

Figure 1
LFG to LNG Flow Diagram as Quoted by Witteman



Acrion Technologies, Inc. November, 2002

Do NGV(s) have a Future?

- **New EPA regulations have eliminated the environmental driver for Natural Gas Vehicles**
- **MBTA has recently selected clean diesel over NGV for its transit bus fleet**
- **Refuse trucks are the only near-term market for natural gas**
- **A fuel-efficient natural gas powered vehicle that meets EPA 2007 emission requirements will be in demand after 2007**
- **Heavy vehicle manufacturers can leverage its expertise on natural gas engines for refuse haulers into new markets after 2007**

